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[TITLE OF THE INVENTION-KOREAN] 멤스소자 및 그의 제작방법
[TITLE OF THE INVENTION-ENGLISH] MEMS device and a fabrication method thereof
[APPLICANT]
[NAME] Samsung Electronics Co., Ltd.
[APPLICANT CODE] 1-1998-104271-3
[EMPOWERED ATTORNEY]
[NAME] Hong-sik JEONG
[ATTORNEY CODE] 9-1998-000543-3
[REGISTRATION NUMBER OF GENERAL POWER OF ATTORNEY] 2000-046970-1
[INVENTOR]
[NAME-KOREAN] 이은성
[NAME-ENGLISH] LEE, EUN SUNG
[RESIDENT REGISTRATION NUMBER] 720831-1406418
[ZIP CODE] 301-758
[ADDRESS] 28-409, Samsung Apartment, Oryu-dong, Jung-gu, Daejon city
[NATIONALITY] KR
[INVENTOR]
[NAME-KOREAN] 김정우
[NAME-ENGLISH] KIM, CHUNG WOO
[RESIDENT REGISTRATION NUMBER] 601107-1090115
[ZIP CODE] 463-750
[ADDRESS] 308-801, Satbyul-Woobang Apartment, 38, Bundang-dong, Bundang-gu, Sungnam city, Gyunggi-do
[NATIONALITY] KR
[INVENTOR]
[NAME-KOREAN] 송인상
[NAME-ENGLISH] SONG, IN SANG

[RESIDENT REGISTRATION NUMBER] 650114-1449020

[ZIP CODE] 151-712

[ADDRESS] 1616, Haetae Boramae Jusang Town, Bongchun-1-dong, Gwanak-gu, Seoul

[NATIONALITY] KR

[INVENTOR]

[NAME-KOREAN] 김종석

[NAME-ENGLISH] KIM, JONG SEOK

[RESIDENT REGISTRATION NUMBER] 740606-1120819

[ZIP CODE] 445-973

[ADDRESS] 101-202, Hyundai Apartment, Sinyoungtong, Banweolree, Tae ahn-eup, Hwasung-gun, Gyunggi-do

[NATIONALITY] KR

[INVENTOR]

[NAME-KOREAN] 이문철

[NAME-ENGLISH] LEE, MOON CHUL

[RESIDENT REGISTRATION NUMBER] 711126-1079810

[ZIP CODE] 463-901

[ADDRESS] 1003-804, Samsung Apartment, Imae-dong, Bundang-gu, Sungnam city, Gyunggi-do

[NATIONALITY] KR

[PURPOSE] I, hereby, submit the present application for the Patent under the Article 42 of the Patent Law.

Agent Hong-sik JEONG (seal)

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[Documents] 1. One copy of Abstract, Specification (drawings)

[ABSTRACT OF THE DISCLOSURE]

[Abstract]

Disclosed is a method for fabricating an MEMS device having a fixing part, driving part, electrode part, and contact parts on a substrate. A driving electrode is formed on the substrate, and a flattening mold is formed as an insulation layer on the substrate on which the driving electrode is formed. The insulation layer is patterned, and the regions of the insulation layer in which the fixing part and the contact parts are formed are etched. Thereafter, a metal layer is formed on the substrate. The metal layer is flattened in correspondence to the time when the insulation layer is revealed, and the driving electrode is formed to have an embedded structure as to the insulation layer. After the flattening step is performed, a sacrificial layer is formed on the substrate, and a groove-shaped space wrapping up a region corresponding to a region in which the fixing part is formed is formed. Next, an MEMS structure layer is formed on the sacrificial layer. Accordingly, sidewalls are formed in the space, and the fixing part and the driving part are formed in the sacrificial layer. Thereafter, the sacrificial layer is removed in use of an etchant, and the sacrificial layer underneath the fixing part is protected by the sidewalls from the etchant and remains. Accordingly, the step-height or thickness difference between the contact parts and the driving electrode is removed by the flattening process, and the sidewalls are formed, so that an MEMS device having the enhanced stability and solidity can be provided.

[The main figure]

Fig. 3f

[Search words]

MEMS, structure, sacrificial layer, anchor, flattening, polishing, sidewall

[SPECIFICATION]

[The title of the invention]

MEMS device and a fabrication method thereof

[The brief description of the drawings]

Fig. 1 is a cross-sectioned side view for schematically illustrating a general MEMS device;

Fig. 2a to Fig. 2e are views for sequentially showing a process for fabricating a general electrostatic drive-type MEMS device;

Fig. 3a to Fig. 3f are views for sequentially showing a process for fabricating an electrostatic drive-type RF MEMS relay according to an embodiment of the present invention; and

Fig. 4a to Fig. 4g are views for sequentially showing a process for fabricating another electrostatic drive-type RF MEMS relay according to another embodiment of the present invention.

* Description of the reference numerals in the drawings *

310,410: substrate	320,420: driving electrode layer
330,430: insulation layer	340,440: metal layer
360,470: MEMS structure layer	

[Detailed description of the invention]

[Object of the invention]

[The field of the invention and the prior art]

The present invention relates to an MEMS device and fabrication method thereof, and more particularly to an electrostatic driving MEMS device having a driving electrode in an embedded structure and fabrication method thereof.

The Micro electro mechanical system is a technology that implements mechanical and electrical parts, using a semiconductor process. The MEMS device generally has driving parts floating to be movable on the substrate in order for the device fabricated in use of the MEMS technology to perform mechanical operations.

Fig. 1 is a view for schematically illustrating such an MEMS device.

The MEMS device has a substrate 10, a fixing part 30 fixed on the substrate 10, and a driving part 40 extended from the fixing part 30. The fixing part 30 is referred to as an anchor or a support in general, fixing the driving part 40 to the substrate 10.

The driving part 40 is spaced to float over the substrate 10, which is upwards and downwards movable as shown in dotted lines by a predetermined driving force occurring from an electrode part 20 formed on the substrate 10. The driving part 40 is fabricated in a shape of such as beam, membrane, or the like depending on necessity.

Fig. 2a to Fig. 2e are views for sequentially illustrating a process for fabricating a general electrostatic drive-type RF MEMS device, as an example.

As shown in Fig. 2a, a driving electrode layer 220 is formed on the substrate 210 through patterning for an electrostatic driving, and metal layers 230 are formed as shown in Fig. 2b to match in shapes with an anchor part as a fixing part fixed on the substrate 210 and an RF lines as input and/or output terminals of an RF signal. At this

time, the metal layer 230 is formed in a thick layer of 2 to 3 μm in consideration of the skin depth effect.

Next, an insulation layer 240 is formed to wrap up the driving electrode layer 220 formed on the substrate 210.

Thereafter, as shown in Fig. 2d, a sacrificial layer 250 is formed on the substrate 210, and the sacrificial layer of the anchor part fixed on the substrate 210 is etched through predetermined patterning. An MEMS structure layer 260 is formed on the patterned sacrificial layer 250, as shown in Fig. 2e.

Thereafter, predetermined etching access holes(not shown) are formed in the driving part 260 of the MEMS structure layer 260, and etchant is supplied through the etching access holes to selectively etch only the sacrificial layer 250. Accordingly, as shown in Fig. 2f, an MEMS device is fabricated that the driving part 260 floats over the substrate 210 through the removal of the sacrificial layer 250.

As stated above, a general fabrication process proceeds regardless of a step-height difference between the metal layers 230 of RF lines and the driving electrode layer 220.

Accordingly, such a step-height difference between the metal layers 230 of RF lines and the driving electrode layer 220 causes the driving part 260 formed by a subsequent procedure to come uneven, as shown in Fig. 2e, so that a fabricated MEMS device becomes less reliable. However, since Such an unevenness is not expected which occurs on the driving part 260 upon designing, there exists a big error between the design and the fabrication process. Further, such an unevenness causes a problem

that brings an incomplete driving when the MEMS device is driven.

Further, in the fabrication process shown in Fig. 2d to Fig. 2e, a connection part 261 of the MEMS structure layer 260 formed on an anchor part and the MEMS structure layer of the driving part 260 floating over the substrate 210 is formed in a bent shape that is relatively thinner than the anchor part and the MEMS structure layer of the driving part.

Accordingly, the connection part in the thin and bent shape causes a problem in the solidity of the MEMS device, upon considering that the general operations of the MEMS device characterizes the movements of the driving part 260.

[Technical object of the invention]

In order to solve the above problems, it is an object of the present invention to provide an MEMS device having the enhanced reliability and stable driving capability and a fabrication method thereof.

[Construction and operation of the invention]

The object of the present invention is achieved by a method for fabricating an MEMS device having a fixing part fixed as to a substrate, a driving part connected to the fixing part floating over the substrate, a driving electrode for driving the driving part by a predetermined driving force, and contact parts switching with the driving part driven by the driving force, comprising steps of patterning and forming the driving electrode on the substrate; forming a flattening mold as an insulation layer on the

substrate on which the driving electrode is formed; patterning the insulation layer and etching regions of the insulation layer on which the fixing part and the contact parts are formed; forming a metal layer on the substrate including the etched regions for the fixing part and the contact parts; and flattening the metal layer in correspondence to the time when the insulation layer is revealed. In the step for forming the flattening mold as the insulation layer, the insulation layer is formed in a thicker film at least than the driving electrode, and the driving electrode has an embedded structure as to the insulation layer.

Preferably, the method, after the flattening step, further comprises steps of forming a sacrificial layer on the substrate; patterning the sacrificial layer to form space wrapping up at least one portion of a region matched with the region in which the fixing part is formed; forming an MEMS structure layer on the sacrificial layer to form sidewalls in the space, and forming the fixing part and the driving part on the sacrificial layer; and removing the sacrificial layer by using an etchant. In the removal step, supplying the etchant into one portion of the sacrificial layer matched with the fixing part is cut off by the sidewalls so that a portion remaining except for the portion of the sacrificial layer wrapped up by the sidewalls is removed.

In the meantime, according to the present invention, an MEMS device comprises a fixing part fixed as to a substrate; a driving part connected to the fixing part and floating over the substrate; an electrode part for driving the driving part; and contact parts switching with the driving part, wherein the electrode part and the contact parts are formed flattened on the substrate. The electrode part includes an electrode and an

insulation layer wrapping up the electrode to electrically isolate the driving part and the electrode, the electrode being formed in an embedded structure as to the insulation layer.

Preferably, the MEMS device further comprises an anchor inserted between the fixing part and the substrate, and for fixing the fixing part on the substrate; and sidewalls wrapping up at least one portion of side surfaces of the anchor.

Accordingly, the step difference between the RF lines and the driving electrode is removed, so the MEMS structure layer to be subsequently formed for the driving part driven by an electrostatic force can be prevented from being transformed.

Hereinafter, the present invention will be described in detail with reference to the accompanying drawings.

An electrostatic drive-type RF MEMS relay is described below as an MEMS device according to an embodiment of the present invention.

Fig. 3a to Fig. 3f are views for sequentially showing a process for fabricating an electrostatic drive-type MEMS relay according to an embodiment of the present invention.

First, as shown in Fig. 3a, a driving electrode layer 320 is formed on a substrate 310 through patterning for electrostatic driving, and, as shown in Fig. 3b, a flattening mold 330 is formed as an insulation layer on the substrate 310 on which the driving electrode layer 320. The Tetra-Ethyl-Ortho-Silicate(TEOS) oxide film is generally used for the insulation layer.

Thereafter, the flattening mold 330 of the insulation layer is patterned, and the regions for an anchor part A of the MEMS relay and contact parts for input and output

terminals of an RF signal are etched. That is, the insulation layer 330 formed in the flattening mold becomes an insulation layer of the driving electrode layer 320. The electrode layer 330 is formed to prevent the electric short-circuit of the driving electrode layer 320 and a driving part to be described later.

Next, as shown in Fig. 3c, a metal layer 340 is formed in a predetermined thickness on the substrate where regions of the anchor part A and the contact part are etched. For example, gold(Au) of metal substance having excellent conductivity is employed for the metal layer 340.

As shown in Fig. 3c, a step is performed for flattening the substrate on which the metal layer 340 is formed in a predetermined thickness. The flattening step is accomplished by polishing.

In case that the flattening step is performed by the polishing, the time when the insulation layer 330 formed underneath the metal layer 340 is revealed is monitored, and it is decided how far the flattening step progresses. That is, as shown in Fig. 3d, the polishing progresses till the insulation layer 330 is revealed.

At this time, the metal layer 340 for the RF lines is formed in a thick film of 2 to 3 μm in consideration of the skin depth effect, for which the flattening mold 330 of the insulation layer is formed in the thick film of at least 2 to 3 μm.

Accordingly, the metal layer 340 is formed on the anchor part A and the RF line parts in a thickness matching the thickness of the insulation layer mold previously processed, so that the electrode part in which the driving electrode layer 320 and the insulation layer 330 are formed and the RF lines are evenly formed in thickness without

a difference of step heights.

Therefore, the electrostatic drive-type MEMS relay is formed in a structure that the driving electrode 320 thereof is embedded in the insulation layer 330.

Next, as shown in Fig. 3e, a sacrificial layer 350 is formed on the flattened substrate 310, and the sacrificial layer is etched to form a groove-shaped space in one rim portion B of the anchor part A through a predetermined patterning. The sacrificial layer 350 may be formed of material such as aluminum(Al), copper(Cu), oxide, nickel(Ni), or the like.

As shown in Fig. 3f, an MEMS structure layer 360 is formed on the patterned sacrificial layer 350. The MEMS structure layer 360 is formed of a deposited metal layer of a substance such as gold(Au). Accordingly, the MEMS structure layer 360 is formed in the groove-shaped space formed in the rim portion B of the anchor part, and the MEMS structure layer 360 is also formed on the substrate 310 on which the sacrificial layer 350 is formed.

Thereafter, predetermined etching access holes(not shown) are formed in the MEMS structure layer 360 in which the driving part 360 is formed which is driven by the driving electrode 320, an etchant able to selectively etch only the sacrificial layer 350 is supplied through the etching access holes. Accordingly, the sacrificial layer 350 is removed, as shown in Fig. 3f, so that the MEMS relay having the driving part 360 floating over the substrate 310 is fabricated.

At this time, a sidewall C is formed in the connection part of the anchor part and the driving part by the MEMS structure layer 360 formed in the rim B of the anchor

part, as shown in Fig. 3f, so that the sacrificial layer 350 adjacent to the connection part is not removed by the etchant, but remains.

The process previously shown in Fig. 3e and Fig. 3f is described in detail in Republic of Korea patent Application No. 2001-80358 entitled "MEMS structure having blocked sacrificial layer supports and a fabrication method thereof", which has been filed by the same Applicant as that of the present invention.

As stated above, the step-height difference, that is, the thickness difference between the RF lines 340 of the contact parts and the driving electrode 320 formed in a structure embedded in the insulation layer 330 of the electrode part are removed through the flattening process, so that an MEMS relay can be fabricated which has the enhanced reliability and stable drive capability.

Further, a step for forming the insulation layer 330 on the driving electrode layer 320 compared to the prior art can be excluded, to thereby simplify a fabrication process.

In the meantime, the sacrificial layer 350 of the anchor part remains by the sidewall C formed in the connection part of the anchor part A and the driving part 360, so that a more solid MEMS device can be fabricated.

Fig. 4a to Fig. 4G are views for sequentially illustrating a flattening process for an electrostatic drive-type MEMS relay according to another embodiment of the present invention, in which a driving electrode layer 420 formed on the substrate 410 is formed without a step-height difference as to metal layers 440 of RF lines.

First, as shown in Fig. 4a, the driving electrode layer 420 patterned and formed

on the substrate 410 is formed in a predetermined thickness for electrostatic driving, and, as shown in Fig. 4b, the insulation layer 430 is formed on the substrate 410 on which the driving electrode layer 420 is formed. Thereafter, the regions of the anchor part A of the MEMS relay and the contact parts of the RF lines are patterned and etched.

Next, as shown in Fig. 4c, the metal layer 440 is deposited in a predetermined thickness on the substrate 410 in which the regions of the anchor part and the contact parts have been etched.

A flattening step is performed through the polishing of the substrate on which the metal layer 440 is formed in a predetermine thickness. As shown in Fig. 4d, the polishing progresses until the driving electrode layer 420 is revealed. Further, the metal layers 440 of the RF lines are polished to be formed in a thick film of 2 to 3 μm in consideration of the skin depth effect.

Next, as shown in Fig. 4e, an insulation layer 450 wrapping up the driving electrode layer 420 is formed.

Accordingly, the metal layers 440 of contact part and the driving electrode layer 420 are formed flattened compared to the prior art.

Next, the fabrication steps of Fig. 4f and Fig. 4g are the same as those of Fig. 3e and Fig. 3f for the above-described embodiment of the present invention which is described in Republic of Korea Patent Application No. 2001-80358, so the description thereto will be omitted.

As stated above, the step-height difference between the RF lines 440 and the driving electrode 420 is removed so that the driving part of MEMS structure layer 470

fabricated in the subsequent steps is prevented from being transformed and a more solid MEMS device can be fabricated.

Accordingly, an MEMS relay having the enhanced reliability and the stabilized drive capability can be fabricated.

[Effect of the invention]

According to the present invention, the step difference between the RF lines and the driving electrode is removed, so the MEMS structure layer to be subsequently formed for the driving part driven by an electrostatic force can be prevented from being transformed.

Further, the sacrificial layer of the anchor part remains by the sidewall formed in the connection part of the anchor part and the driving part, so that a more solid MEMS device can be fabricated.

Although the preferred embodiments of the present invention have been described, it will be understood by those skilled in the art that the present invention should not be limited to the described preferred embodiments, but various changes and modifications can be made within the spirit and scope of the present invention as defined by the appended claims.

What is claimed is:

1. A method for fabricating an MEMS device having a fixing part fixed as to a substrate, a driving part connected to the fixing part floating over the substrate, a

driving electrode for driving the driving part by a predetermined driving force, and contact parts switching with the driving part driven by the driving force, comprising steps of:

patterning and forming the driving electrode on the substrate;

forming a flattening mold as an insulation layer on the substrate on which the driving electrode is formed;

patterning the insulation layer and etching regions of the insulation layer on which the fixing part and the contact parts are formed;

forming a metal layer on the substrate including the etched regions for the fixing part and the contact parts; and

flattening the metal layer in correspondence to the time when the insulation layer is revealed.

2. The method as claimed in claim 1, wherein, in the step for forming the flattening mold as the insulation layer, the insulation layer is formed in a thicker film at least than the driving electrode, and the driving electrode has an embedded structure as to the insulation layer.

3. The method as claimed in claim 1, after the flattening step, further comprising steps of:

forming a sacrificial layer on the substrate;

patterning the sacrificial layer to form space wrapping up at least one portion of

a region matched with the region in which the fixing part is formed;

forming an MEMS structure layer on the sacrificial layer to form sidewalls in the space, and forming the fixing part and the driving part on the sacrificial layer; and

removing the sacrificial layer by using an etchant, wherein, in the removal step, supplying the etchant into one portion of the sacrificial layer matched with the fixing part is cut off by the sidewalls so that a portion remaining except for the portion of the sacrificial layer wrapped up by the sidewalls is removed.

4. The method as claimed in claim 3, wherein, in the step for forming the space, the space is substantially formed over the entire portion remaining except for the portion matched with a connection part connecting the fixing part and the driving part.

5. The method as claimed in claim 3, wherein a width of the connection part is narrower than that of the fixing part.

6. The method as claimed in claim 3, before the removal step is performed, further comprising a step for etching access holes are formed in the MEMS structure layer.

7. The method as claimed in claim 3, wherein the etching access holes are formed in the driving part.

8. A method for fabricating an MEMS device having a fixing part fixed as to a substrate, a driving part connected with the fixing part and floating over the substrate, a driving electrode for driving the driving part by a predetermined driving force, and contact parts switching with the driving part driven by the driving force, comprising steps of:

patterning and forming the driving electrode on the substrate;

forming an insulation layer on the substrate on which the driving electrode is formed;

patterning the insulation layer and etching portions of the insulation layer on which the fixing part and the contact parts are formed;

forming a metal layer on the substrate including the etched regions for the fixing part and the contact parts;

flattening the metal layer in correspondence to the time when the driving electrode is revealed; and

forming an insulation film wrapping up the driving electrode to electrically isolate the driving electrode and the driving part.

9. The method as claimed in claim 8, after the step for forming the insulation film, further comprising steps of:

forming a sacrificial layer on the substrate;

patterning the sacrificial layer to form space wrapping up at least one portion of a region matched with the region in which the fixing part is formed;

forming an MEMS structure layer on the sacrificial layer to form sidewalls in the space, and forming the fixing part and the driving part on the sacrificial layer; and

removing the sacrificial layer by using an etchant, wherein, in the removal step, supplying the etchant into one portion of the sacrificial layer matched with the fixing part is cut off by the sidewalls so that a portion remaining except for the portion of the sacrificial layer wrapped up by the sidewalls is removed.

10. The method as claimed in claim 9, wherein, in the step for forming the space, the space is substantially formed over the entire portion remaining except for the portion matched with a connection part connecting the fixing part and the driving part.

11. The method as claimed in claim 9, wherein a width of the connection part is narrower than that of the fixing part.

12. The method as claimed in claim 9, before the removal step is performed, further comprising a step for etching access holes are formed in the MEMS structure layer.

13. The method as claimed in claim 9, wherein the etching access holes are formed in the driving part.

14. An MEMS device, comprising:

a fixing part fixed as to a substrate;

a driving part connected to the fixing part and floating over the substrate;

an electrode part for driving the driving part; and

contact parts switching with the driving part, wherein the electrode part and the contact parts are formed flattened on the substrate.

15. The MEMS device as claimed in claim 14, wherein the electrode part includes an electrode and an insulation layer wrapping up the electrode to electrically isolate the driving part and the electrode, the electrode being formed in an embedded structure as to the insulation layer.

16. The MEMS device as claimed in claim 14, further comprising:

an anchor inserted between the fixing part and the substrate, and for fixing the fixing part on the substrate; and

sidewalls wrapping up at least one portion of side surfaces of the anchor.

17. The MEMS device as claimed in claim 15, wherein the sidewalls are substantially formed over the entire portion remaining except for a portion corresponding to a connection part connecting the fixing part and the driving part.

18. The MEMS device as claimed in claim 15, wherein a width of the connection part is narrower than that of the fixing part.

19. The MEMS device as claimed in claim 15, wherein the sidewalls, fixing part, and driving part are formed in one body.

20. The MEMS device as claimed in claim 15, wherein the sidewalls are in contact with the substrate.